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(54) IMPROVEMENTS IN FUEL-INJECTION VALVES FOR INTERNAL COMBUSTION ENGINES

(71) We, DAIMLER - BENZ AKTIENGESELLSCHAFT, of Stuttgart-Untertürkheim, Germany, a Company organised under the laws of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns improvements relating to fuel-injection valves, for internal combustion engines, having a jet needle which is liftable to an open position in the valve body by fuel pressure in the jet chamber.

Hitherto injection valves have generally worked with fuel storage. The storage may be under a spring-loaded piston raised by the fuel, but it may be effected simply by compression of the fuel, which is stored in proximity to and in communication with the fuel-injection point. A loading spring pressing the needle on to its relatively small seat must be so powerful that it becomes compressed only at a predetermined, frequently very high, valve-opening pressure. Injection can then take place and persists until the pressure of the stored fuel has fallen to such an extent that the loading spring presses the needle back on to its seat.

The invention seeks to provide constructionally simple and inexpensive but effective fuel-injection means which will satisfy modern requirements, with respect to accuracy and rapidity of injection, arising from the increasing power of highly loaded internal combustion engines.

According to the invention there is provided a fuel-injection valve, for an internal combustion engine, comprising a jet needle raisable from a valve seat in a valve body by the pressure of fuel in a jet chamber, wherein the upstream end of the jet needle communicates with a control chamber to which fuel is supplied through a throttle by means of a fuel supply duct which also supplies fuel to the jet chamber and piezo-electrically operated control means are provided which control the pressure in the control chamber, in such a manner that opening of said control chamber by means of said control means releases the previously established fuel pressure in the control chamber which was simultaneously acting on the jet needle to press the needle against the valve seat, the reduction of pressure in the control chamber enabling the fuel pressure in the jet chamber to raise the jet needle from the valve seat.

The piezo-electrically operated control means, may, for example, comprise a valve or piston or the like which is preferably disposed at the lower end of a ceramic column provided with interconnected electrodes laid in helical grooves in the column.

The valve body may be provided with an outlet duct from the control chamber controlled by the piezo-electrically operated control valve.

One embodiment of the invention by way of example is illustrated in the accompanying drawing, which is a longitudinal section through a fuel injection valve.

The fuel injection valve 1 is connected by a fuel-supply pipe 2 to a high-pressure reservoir (not shown) and consists essentially of a valve body 3 in which a jet needle 4 is longitudinally slidably guided. The jet needle 3 is stepped in diameter, its smaller cross section being towards a lower valve seat 5. The upper, larger diameter portion 6 slides in the body 3, while the lower portion 7 is surrounded by an annular space 8 which becomes filled with fuel under pressure and into which the pipe 2 leads by way of a jet chamber 9. A supply passage 11 branched from the pipe 2 and provided with a constriction or throttle 10 leads into a control chamber 12, in which fuel pressure can build up and be released, located above or upstream of the needle 4 and bounded above by a piezo-electrically operated control valve 13. The valve 13, axially slidable with the lower end of a ceramic column 14 controls the communication of the control chamber with an outlet duct 21 and thus regulates the fuel injection by electric means, as hereinafter described. Instead of the valve 13, if desired,

a piston may be attached to the lower end of the column 14 for the effective control of fuel injection by electric means. With this arrangement, the piston should be provided with sealing means and the duct 21 is not necessary. The ceramic column 14 above the valve 13 comprises a number of superimposed cylinders and is provided with helical grooves in which electrodes 15 are laid. High voltage for operating the column 14 is produced in a pulse transformer 16, which directly surrounds the column. The cavity between the two parts 14 and 16 is filled with a resilient composition 17.

The manner of operation of the injection valve is as follows:

Fuel flowing under high pressure from the reservoir into the pipe 2, passes on the one hand into the jet chamber 9 and on the other hand through the supply duct 11 with its constriction or throttle 10 into the control chamber 12 between the valve 13 and the upstream end of the needle 4. Thereafter, the resultant force produced as a result of the fluid pressure acting on the larger surface of the needle 4 in the chamber 12, presses the needle on to its seat 5 and obturates the central passage 18 from which two injection holes 19 and 20 branch laterally in the valve body. If a low-voltage rectangular pulse of short duration is applied to the primary side of the transformer, the resultant high-voltage pulse on the secondary side will cause the ceramic column 14 to contract very slightly in length, opening the valve 13. The fuel pressure built up in the control chamber 12 collapses, for which purpose it is necessary that the cross-section of the passage opened by the valve 13 should be greater than that of the narrowest part of the constriction or throttle 10. Due to the pressure collapse, the jet needle will be lifted off its seat 5 by fuel pressure in the jet chamber 9, so that fuel can issue through the passage 18 and injection holes 19 and 20. At the same time, part of the fuel in the control chamber 12 will penetrate past the opened valve 13 and be carried away to the fuel reservoir through the outlet 21. After termination of the valve pulse on the primary side of the transformer, the ceramic column will re-expand axially due to the reversal of voltage on the secondary side and return the valve 13 to the closed position. Because of the build-up of pressure which then occurs, downstream of the constriction 10, in the control chamber 12, the jet needle 4 will be pressed back against its seat 5. Communication between the pipe 2 and the passage 18 is thus cut off again until the operation is repeated in response to relief of pressure in the control chamber 12.

The necessary fuel pressure may be provided by a continuously working pump and may amount to a constant value of about 300 kg per cm^2. The timing of the fuel injection and the amount injected are determined by the low-voltage pulse. With this arrangement, mechanical injection-timing means is not required.

As the fuel control is basically electrical, the disadvantage of conversion from an electric quantity to a mechanical regulating quantity for producing the control movement of a conventional injection pump is eliminated.

WHAT WE CLAIM IS:—

1. A fuel injection valve for an internal combustion engine comprising a jet needle raisable from a valve seat in a valve body by the pressure of fuel in a jet chamber, wherein the upstream end of the jet needle communicates with a control chamber to which fuel is supplied through a throttle by means of a fuel supply duct which also supplies fuel to the jet chamber and piezo-electrically operated control means are provided which control the pressure in the control chamber, in such a manner that opening of said control chamber by means of said control means releases the previously established fuel pressure in the control chamber which was simultaneously acting on the jet needle to press the needle against the valve seat, the reduction of pressure in the control chamber enabling the fuel pressure in the jet chamber to raise the jet needle from the valve seat.

2. A valve according to claim 1 wherein the piezo-electrically operated control means includes a control valve provided at one end of a ceramic column.

3. A valve according to claim 2 wherein the valve body is provided with an outlet duct from the control chamber controlled by said control valve.

4. A valve substantially as hereinbefore described with reference to the accompanying drawing.

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1320057 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*